**Online supplementary material Appendix S2.**

**Calibration of $^{25}$Mg implant into NIST SRM 617 glass: Details**

For convenience, manuscript Figure 3 is attached at the end of this file.

Two replicate back-to-back profiles were measured on each of three NIST SRM 617 glass disks. The $^{24}$Mg/$^{28}$Si counting rate profiles were similar for all six analyses of the implanted 617 glass but with some variations in the depth at which $^{24}$Mg/$^{28}$Si became constant (manuscript Figure 4) due to transient effects.

For profiles like those shown in Figure 3, with a constant $^{24}$Mg counting rate, it is possible to avoid errors due to the differences in transients between Mg and Si by calculating the $^{25}$Mg implant fluence without using the $^{28}$Si matrix data:

$$n_i(x) = n_o \left[ {}^{25}\mathrm{Mgi}\,(x) \,/\, {}^{25}\mathrm{Mg}_o \right] \qquad \text{(S1)}$$

where $n_i(x)$ is the $^{25}$Mg implant concentration (atoms cm$^{-3}$) at depth x, and $n_o$ is the known atomic concentration of $^{25}$Mg in the NIST 617 glass. Here the symbol $^{25}$Mg refers to counting rate and i means implant, i.e., the background $^{25}$Mg$_o$ from the NIST SRM 617 glass $^{25}$Mg was subtracted from the measured $^{25}$Mg(x) to give the implant $^{25}$Mgi(x) at that depth.

Not all profiles were as good as that shown in Figure 3. A stepwise primary ion beam current drop of 4% was observed in one of six profiles, but the remaining five were constant to better than 1%. In contrast, for these 5 profiles, the $^{24}$Mg counting rate decreased from 40 nm to the end of the profile by 2% to 11%, indicating detuning of the secondary ion beams, probably from charging. However, as illustrated in manuscript Figure 4, the $^{24}$Mg/$^{28}$Si ratio beyond around 100 nm was constant in all six profiles. Thus a small correction to the $n_i(x)$ from equation (B1) can be made based on the changes in $^{24}Mg$ secondary ion intensity:

$$n_i(x)corr = n_i(x) \left[ {}^{24}Mg\ (x) / {}^{24}Mg_o \right] \qquad \text{(S2)}$$

where $^{24}Mg$ (x) is the measured $^{24}Mg$ counting rate at depth x and $^{24}Mg_o$ is the $^{24}Mg$ counting rate deep in the sample, averaged over the same depth range as used for $^{25}Mg_o$ in Equation (S1). The factor in brackets is the small correction for sensitivity drifts. Using Equation (S2), which is equivalent to normalising to $^{24}Mg$, also corrects for the transient effects in Mg below 60 nm, as discussed above. The integral of $n_i(x)corr$ gives the fluence. Our adopted fluence of 2.62 x $10^{13}$ $cm^{-2}$ was calculated from Equation (S2).

The fluences calculated with Equation (S2), which avoids the observed transient effects by not using $^{28}Si$, are more accurate than fluences calculated using $^{28}Si$ normalisation and manuscript Equations (2) and (3). However, the latter give values that agree to within 1%. This good agreement in part reflects the relatively deep implant, but comparison of the depth scales of manuscript Figures 3 and 4 shows that transient effects are still present well into the $^{25}Mg$ profile. The small magnitude of the transient effects in the $^{24}Mg/^{28}Si$ counting rate ratio (manuscript Figure 4) is more important; it may be that the use of the $O_2$ flood has suppressed the magnitude of the transient effects, if not their duration; however, more work would be required to prove this. Although transient effects are not significant in this case, they must always be considered, especially if an implant of a mono-isotopic element is being calibrated, where the approach illustrated by Equation (S2) is not possible.

***Results***. Two replicate back-to-back profiles were measured on each of the three glass disks. The reproducibility in the derived $^{25}Mg$ fluences from the three pairs of analyses was good: percent deviations were 1.5, 0.2 and < 0.1%. In units of $10^{13}$ $cm^{-2}$, the fluences from the three disks agree well: 2.58, 2.66, and 2.61, giving a standard deviation of 1.5%. More work would be required to completely prove that the Mg in our set of NIST SRM 617 glass samples is homogeneous, but this agreement supports our assumption of uniform Mg concentration within our set of NIST 617 glass disks. The 1.5% standard deviation of the average fluences of the three separate 617 glass samples determines the precision of the calibration. Folding in the uncertainty in the measurement of the Mg concentration of the NIST 617 glass gives a total uncertainty of around 4% (1*s*). Our adopted fluence was $2.62 \times 10^{13}$ $cm^{-2}$. The average measured fluence was 87% of the nominal fluence.

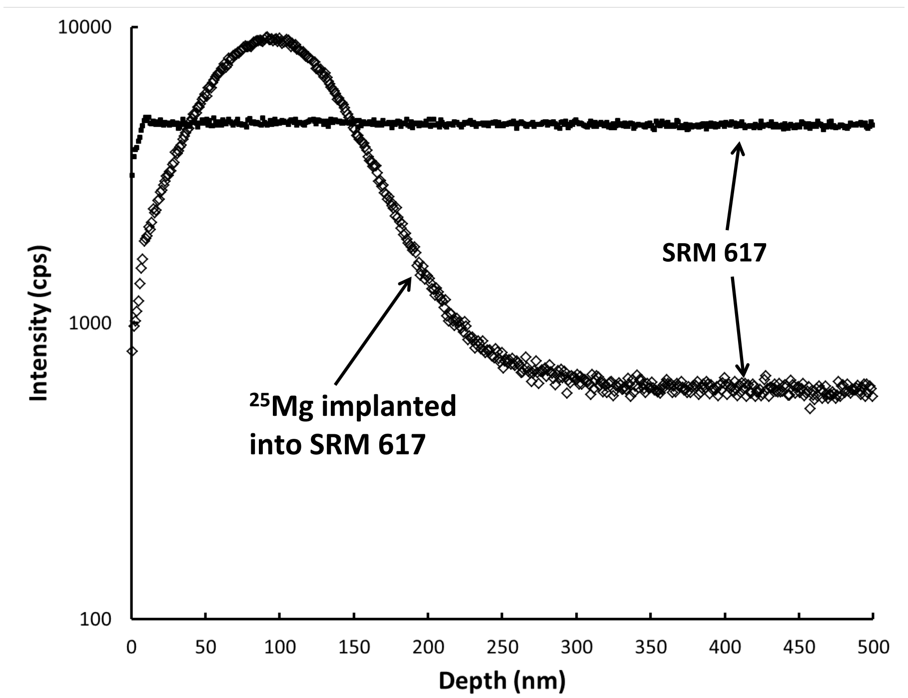
Our ICP-MS concentration for our batch of NIST SRM 617 glass, $26.5 \pm 0.4$ μg $g^{-1}$, was lower than the concentrations tabulated in the GeoReM database, 34.8 to 37 μg $g^{-1}$ for NIST SRM 616 glass. The 616 and 617 glasses are from the same original NIST soda-lime glass, nominally differing only in the marketed thickness. However, Mg is a contaminant, not a deliberately added, certified element, in the NIST SRM 616/617 glasses; consequently, our concerns about potential heterogeneity of Mg appear to have been valid.

**References**

GeoREM database.

http://georem.mpch-mainz.gwdg.de/

Figure 3



10000
1000
100
Intensity (cps)
0
50
100
150
200
250
300
350
400
450
500
Depth (nm)
SRM 617
25Mg implanted into SRM 617